LIPIDS

Lipids include fats, oils, waxes, cholesterol, other sterols, and most steroids. In the body, fat serves as a source of energy, a thermal insulator and cushion around organs, and an important cellular component. The fat-soluble vitamins are A, D, E, and K. You are probably most familiar with the nutritional aspects of dietary fats and oils. Since fats have 2.25 times the energy content of carbohydrates and proteins, most people try to limit their intake of dietary fat to avoid becoming overweight. The food industry has a big market for low-fat and non-fat foods. Just take a look around your local grocery stores!

Lipids are classified as organic compounds that are soluble (dissolvable) in organic solvents, but only sparingly soluble in water. Lipids are biologically important for making barriers (membranes of animal cells), which control the flow of water and other materials into a cell.

Fats and **oils** make up 95% of food lipids and phospholipids, and sterols make up the other 5%. Traditionally, fats were considered to be solid at room temperature, and oils were considered to be liquid. However, this designation is often used to distinguish between fats and oils from animals and plants, respectively. Animal fats are found in meats (beef, chicken, lamb, pork, and veal), milk products, eggs, and seafood (fish oil). Plant (vegetable) oils come from nuts (peanuts), olives, and seeds (soybean, canola, safflower, and corn). We use lipids for flavor (butter and olive oil), to cook foods (oils and shortening), to increase the palatability of foods by improving the texture or "mouthfeel" (cakes, creamy ice cream), and in food processing (emulsifiers).

Fatty acids are generally long, straight chains of carbon atoms with hydrogen atoms attached (**hydrocarbons**) with a carboxylic acid group (COOH) at one end and a methyl group (CH_3) at the other end. These long, straight chains combine with the **glycerol** molecule (see **Figure 1A**) to form lipids (glycerol lipids).

Nomenclature for Fats

If all the bonds are single, the fatty acid molecule is **saturated,** because the maximum number of hydrogen atoms is associated with the carbon atoms. Some examples are tallow (beef fat), lard (pork fat), and butter (milk fat). If there is a double bond among the carbon atoms, the fatty acid molecule is **unsaturated**. Examples of unsaturated fats are canola oil, corn oil, cottonseed oil, and soybean oil. If there are multiple double bonds (two or more), it is called **polyunsaturated**. You may recall seeing the saturated, unsaturated, and polyunsaturated terms with respect to nutritional aspects of oils. Corn and soybean oils are some of the most important food sources of polyunsaturated fatty acids in our food supply. Shown below are the shorthand notation used to describe some important food sources of 18-carbon (C18) fatty acids.

- C18:0 is a fully saturated 18-carbon fatty acid called stearic acid.
- C18:1 has one double bond, between carbons 9-10, (18:1n9) counting from the COOH end, and is called oleic acid.
- C18:2 has two double bonds, between carbons 9-10 and 12-13, counting from the COOH end, and is called linoleic acid (9,12-octadecadienoic acid or 18:2n6).
- C18:3 has three double bonds at carbons 9-10, 12-13, and 15-16, counting from the COOH end, and is called linolenic acid (9,12,15-octadecatrienoic acid or 18:3n3).

The number of fatty acids joined to the glycerol molecule also plays a part in how the molecule is named. If only one fatty acid is connected, the general name for the molecule is a **monoacylglycerol**. If two are joined, the molecule is called a **diacylglycerol,** and if three are joined, a **triacylglycerol**. The bond between the fatty acid and the glycerol also has a special name. It is called an **ester bond** (see **Figure 1F**). The carboxyl end (COOH) of the fatty acid molecule attaches to one of the -OH groups of the glycerol molecule. Because of this combination, an -OH group and -H are left, which combine to form a water molecule.

Since triacylglycerols have three fatty acids, you can get mixed-fatty-acid triacylglycerols, in which there are different fatty acids on each of the glycerol bonds. Naturally occurring soybean oil is a mixed triacylglycerol, containing saturated, monounsaturated, and polyunsaturated fatty acids. Soybean oil contains more monounsaturated and polyunsaturated fatty acids than saturated fatty acids.

Surfactant is a short term for surface-active agent. Polar lipids, like lecithin in soybean oil, serve as specialized surfactants known as **emulsifiers**. By interacting with water on one end of the molecule and repelling water on the other end, emulsifiers keep fat globules dispersed in water or water droplets dispersed in fat. Lipid surfactants are important to our own cellular functions, as well as useful in stabilizing specific food products. **Lecithin** is a phospholipid, which functions as a surfactant. Lecithin and other phospholipid emulsifiers are found in food from animal and plant sources. The food sources of lecithin are eggs, milk, cheese, and soybean oil. These chemical properties of lecithin are used in the food industry to prevent fats from separating out of chocolate, mayonnaise, peanut butter, and salad dressings.

The fats that you see in raw beef, chicken, and pork are known as visible fats. These fats are in plain view and are solid at room temperature. Vegetable oils are also visible fats. The fats that are in snack foods, cookies, desserts, and candy are known as invisible fats. Although you cannot see them, they can add extra calories to your diet.

Activity Objective

In this experiment, we will be extracting and examining the fat in chocolate, potato chips, and sunflower seeds. In chocolate, sugar and cocoa are dispersed in a crystallized fat matrix. To keep the fat from separating out of the chocolate, an emulsifier called lecithin is used. The fat in the potato chip is mostly on the surface of the chip from the frying process. The fat in the sunflower seed is in the seed itself. The cooking oils that we use come primarily from nuts and seeds. Examples of these fat sources are corn, soybean, and peanut oils.

Materials Required

Chocolate chips (semi-sweet)
Sunflower seeds
Potato chips
Acetone
100-mm Petri dishes
100-and 600-milliliter beakers
Graduated cylinder

Balance or scale

Paper towels
Foil
Hammer
Safety goggles
Latex or rubber gloves

Part B. Quantitative measurement of invisible fats from foods

Part 1. Extraction of Fat from Chocolate Chips

1. Weigh out 5 grams (9 chips) of chocolate chips. Crush the chocolate between two sheets of foil with a hammer.
2. Label the beakers that you are using to put the food in, one each for chocolate chips, potato chips, and sunflower seeds. Record the weights of the labeled beakers.
3. Using the beaker that is labeled for chocolate chips and place the crushed chocolate chips in the beaker. Record the weight with the crushed chocolate chips.
4. Add 10 milliliters of acetone to the crushed chocolate chips in the beaker.
5. Swirl for 1 minute in a hood, or stir with a glass rod (in a well ventilated area).
6. Carefully decant the acetone into the Petri dish, making sure the chocolate remains in the beaker.
7. Add 10 milliliters of acetone to the chocolate and repeat steps 5 and 6.
8. Allow the acetone in the Petri dish to dry overnight in a hood (or a well ventilated area) to visualize the lipid that was extracted.
9. Allow the beaker with the chocolate to dry overnight. Weigh the beaker with the chocolate.

Part 2. Extraction of Fat from Potato Chips

1. Weigh out 5 grams of potato chips. Break into dime-size pieces with your fingers.
2. Repeat steps 2–9 in Part 1.

Part 3. Extraction of Fat from Sunflower Seeds

1. Weigh out 5 grams of sunflower seeds. Crush the seeds between two pieces of foil with a hammer.
2. Repeat steps 2–9 in Part 1.

DATA TABLE – EXTRACTION OF LIPIDS

Food	Weight of beaker	Weight of beaker with food	Weight of food	Weight of beaker with dried food	Weight lost from food	% Lipid extraction
Chocolate chips						
Potato chips						
Sunflower seeds						

(weight of beaker with food) – (weight of beaker) = weight of food

(weight of beaker with food) – (weight of beaker with dried food) = weight lost from food

$$\frac{\text{weight lost from food}}{\text{weight of food}} \times 100 = \text{\% lipid extracted}$$

DATA TABLE – DESCRIPTION OF FATS

Food	Color	Texture	Odor	Viscosity
Chocolate chips				
Potato chips				
Sunflower seeds				

Viscosity- The thickness of a substance; how easily it flows.

Questions

1. Explain why acetone was used as a solvent for this experiment.

2. Rank from most to least the percentage of lipid extracted from all three foods. Look at the Nutrition Facts label on the packages of all three foods and rank them. Did your ranking agree with the ranking of the product labels?

3. Determine which lipids contained saturated and unsaturated fatty acids in this experiment, based on your descriptions of the fats in the Petri dishes.